Package ‘edrGraphicalTools’

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Description Reduction methods through slice inverse regression approaches. It mainly designed for illustrating the articles ``A graphical tool for selecting the number of slices and the dimension of the model in SIR and SAVE approaches'' (Liquet, B., Saracco, J. (2012) <doi:10.1007/s00180-011-0241-9>) and "Comparison of sliced inverse regression approaches for underdetermined cases".
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Description

This package illustrates the articles listed below. It estimates by bootstrap a squared trace correlation criterion which measures the quality of the estimation of the effective dimension reduction (EDR) space. It also contains functions to perform such an estimation when the sample size is smaller than the number of explanatory variables. Methods to select the relevant explanatory variables are also included.

Details

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References


See Also
criterionRkh, edr, plot.criterionRkh, edrSelec, edrUnderdet
## Examples

```r
## Sample generation
set.seed(10)
n <- 500
p <- 10
beta <- c(1,rep(0,p-1))
X <- rmvnorm(n,sigma=diag(p))
eps <- rnorm(n)
Y <- (X%*%beta)**3+eps*((X%*%beta)**2)

## Determining optimal values for H and K
grid.H <- c(2,5,10,15,20)
grid.K <- 1:p
#plot(res1,choice.H=c(2,5),choice.K=c(1,2))
HK <- which(res1$Rkhbootmean[,1:(p-1)] == max(res1$Rkhbootmean[,1:(p-1)]),
arr.ind=TRUE)[1,]
H <- grid.H[HK[1]]
K <- grid.K[HK[2]]

## Selecting relevant variables in X
if (K==1) {
  res2 <- edrSelec(Y, X, H, K, "CSS", pZero=p/2, NZero=200, zeta=0.05)
  dev.new()
  plot(res2)
  if (1 %in% which(res2$scoreVar == max(res2$scoreVar))) {
    message("The first variable is selected, as it should be.")
  } else {
    message("The variable selection failed.")
  }
} else {
  message("The choice of K failed.")
}
```

---

### criterionRkh

**Estimation of the Rkh criterion by bootstrap method**

#### Description

This is the main function in the `edrGraphicalTools` package. This function estimates the square trace correlation criterion Rkh by bootstrap in order to simultaneously choose the number H of slices and the dimension K of the EDR space reduction. It creates objects of class `criterionRkh`. Several helper functions that require a `criterionRkh` object can then be applied to the output from this function.

#### Usage

```r
criterionRkh(Y, X, H, K, indices, B = 50, method)
```
Arguments

- **Y**: A numeric vector representing the dependent variable (a response vector).
- **X**: A matrix representing the quantitative explanatory variables (bind by column).
- **H**: An integer vector representing the different number of slices to be investigated. By default, H takes integer values in \(2, 3, \ldots, \text{round}(n/4)\); \(n\) is the sample size.
- **K**: An integer vector representing the different dimension \(K\) to be investigated. By default, \(K\) takes integer values in \(1, 2, \ldots, \min(p, 25)\); \(p\) is the number of explanatory variables.
- **indices**: An optional integer vector specifying the indices of the bootstrap samples. By default, non-parametric resampling is performed. If used, an integer vector of length \(B\times n\) will be specified; \(n\) is the length of \(Y\).
- **B**: The number of bootstrap replicates. By default, \(B\) equals 50.
- **method**: This character string specifies the method of fitting. The options include "SIR-I", "SIR-II", and "SAVE".

Details

We are interested in the following semiparametric dimension reduction model proposed by Li (1991):

\[
y = f(b_1'x, b_2'x, \ldots, b_K'x, e)
\]

where the univariate response variable \(y\) is associated with the \(p\)-dimensional regressor \(p\) only through the reduced \(K\)-dimensional variable \((b_1'x, b_2'x, \ldots, b_K'x)\) with \(K < p\). The error term \(e\) is independent of \(x\). The link function \(f\) and the \(b\)-vectors are unknown. We are interested in finding the linear subspace spanned by the \(K\) unknown \(b\)-vector, called the effective dimension reduction (EDR) space. We focus on the SIR (named SIR-I), SIR-II and SAVE methods to estimate the EDR space. The slicing step of these methods depends on the number \(H\) of slices. We propose a naive bootstrap estimation of the square trace correlation criterion to allow selection of an "optimal" number of slices and to simultaneously select the corresponding suitable dimension \(K\) (number of the linear combinations of \(x\)).

Value

criterionRkh returns an object of class criterionRkh (the name of the type is the value of the method argument), with attributes:

- **Rkhbootmean**: A matrix corresponding of the estimation by bootstrap of the square trace criterion \(Rkh\) (\(h\) in rows and \(k\) in columns).
- **Rkhboot**: A list including the result of the estimation of the square trace criterion for each bootstrap replicate.
- **method**: the dimension reduction method used.
- **n**: Number of subject.
- **H**: A vector representing the different numbers \(H\) of slices investigated.
- **K**: A vector representing the different dimensions \(K\) investigated.
- **indices**: An vector of integers representing the indices of the bootstrap sample used.
Author(s)

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References


See Also

edr, summary.criterionRkh, plot.criterionRkh

Examples

```r
## simulated example 1
set.seed(10)
n <- 500
beta <- c(1,rep(0,9))
X <- rmvnorm(n,sigma=diag(10))
eps <- rnorm(n)
y <- (X%*%beta)**3+eps*((X%*%beta)**2)
## Choice a grid of values for H
grid.H <- c(2,5,10,15,20,30)
res1 <- criterionRkh(y,X,grid.H,B=50,method="SIR-I")
res1
#plot(res1,choice.H=c(2,5),choice.K=c(1,2))
## Estimation for SIR-II method with the same bootstrap replicate than for SIR-I
res2 <- criterionRkh(y,X,grid.H,indices=res1$indices,B=50,method="SIR-II")
res2
```

edr

*Main function for estimation of the EDR space*

Description

It creates objects of class edr to estimate the effective dimension regression (EDR) space. Several helper functions that require an edr object can then be applied to the output from this function.

Usage

`edr(Y, X, H, K, method, submethod="SIR-QZ", ...)`
Arguments

- **Y**: A numeric vector representing the dependent variable (a response vector).
- **X**: A matrix representing the quantitative explanatory variables (bind by column).
- **H**: The chosen number of slices.
- **K**: The chosen dimension K.
- **method**: This character string specifies the method of fitting. The option includes "SIR-I", "SIR-II", and "SAVE".
- **submethod**: This character string specifies the method of fitting when the number of lines of X is greater than its number of columns. It should be either "SIR-QZ", "RSIR" or "SR-SIR".
- ...: Arguments to be passed to edrUnderdet when the number of lines of X is greater than its number of columns.

Details

We are interested in the following semiparametric dimension reduction model proposed by Li (1991)

\[ y = f(b_1'x, b_2'x, ..., b_K'x, e) \]

where the univariate response variable y is associated with the p-dimensional regressor p only through the reduced K-dimensional variable \((b_1'x, b_2'x, ..., b_K'x)\) with \(K < p\). The error term e is independent of x. The link function f and the b-vectors are unknown. We are interested in finding the linear subspace spanned by the K unknown b-vector, called the effective dimension reduction (EDR) space. We focus on the SIR, SIR-II and SAVE methods to estimate the EDR space. The slicing step of these methods depends on the number \(H\) of slices. We propose with the function criterionRkh a naive bootstrap estimation of the square trace correlation criterion to allow selection of an “optimal” number \(H\) of slices and simultaneously the corresponding suitable dimension \(K\) (number of the linear combination of x). After choosing an optimal couple \((H, K)\) for the best estimation method (the square trace correlation criterion closest to one), the EDR space could be estimate with this function. Each method consists in a spectral decomposition of a matrix of interest. The eigenvectors of this matrix associated of the K largest eigenvalues are EDR directions.

Value

edr returns an object of class edr, with attributes:

- **matEDR**: A matrix corresponding of the eigenvectors of the interest matrix
- **eigvalEDR**: The eigenvalues of the matrix of interest
- **K**: The chosen dimension.
- **H**: The chosen number of slices.
- **n**: Sample size.
- **method**: The dimension reduction method used.
- **X**: The matrix of the quantitative explanatory variables (bind by column).
- **Y**: The numeric vector of the dependent variable (a response vector).
edrSelec

Author(s)

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References


See Also

criterionrk, summary.edr, plot.edr

Examples

```r
set.seed(10)
n <- 500
beta1 <- c(1,1,rep(0,8))
beta2 <- c(0,0,1,1,rep(0,6))
X <- rmvnorm(n,sigma=diag(1,10))
eps <- rnorm(n)
Y <- (X%*%beta1)**2+(X%*%beta2)**2+eps

## Estimation of the trace square criterion
## grid.H <- c(2,5,10,15,20,30)
## res2 <- criterionrk(Y,X,H=grid.H,B=50,method="SIR-II")
## summary(res2)
## plot(res2)

## Estimation of the EDR direction for K=2 and H=2 and SIR-II method
edr2 <- edr(Y,X,H=2,K=2,method="SIR-II")
summary(edr2)
#plot(edr2)
```

edrSelec

Variable selection based on sliced inverse regression

Description

Gathers several procedures to determine which explanatory variables have an effect on a dependent variable. Works whether there are more explanatory variables than observations or not. Creates an object of class edrSelec.
edrSelc

Usage

edrSelc(Y, X, H, K, method, pZero=NULL, NZero=NULL, zeta=NULL, rho=NULL, baseEst=NULL, btspSamp=NULL, lassoParam=NULL)

Arguments

Y A numeric vector representing the dependent variable (a response vector).
X A matrix representing the quantitative explanatory variables (bind by column).
H When method="SR-SIR" or method="RSIR", the chosen number of slices. When method="CSS", a vector with various numbers of slices.
K The chosen dimension K.
method This character string specifies the selection method. It should be either "CSS", "RSIR" or "SR-SIR".
pZero When method="CSS", the number of variables to pick when creating a submodel.
NZero When method="CSS", the number of submodels to create.
zeta When method="CSS", the proportion of 'best' submodels selected from the NZero submodels.
rho When method="CSS", and if zeta is not provided, the threshold above which a submodel is considered as 'best'. It must be a real in ]0,1[.
baseEst An initial estimate of the EDR space on which each method relies.
btspSamp When method="RSIR", the bootstrap sample size for estimating the asymptotic distribution of the estimated EDR directions.
lassoParam When method="SR-SIR", a vector of lasso parameters from which the optimal one is chosen, using the RIC criterion.

details

The "CSS" method builds NZero submodels using only pZero explanatory variables. It estimates the indices for each of them. The squared correlation between these indices and those found with the whole set of explanatory variables is computed. Only the submodels with the highest squared correlation are kept. The method then counts how many times each explanatory variable appears in these 'best' submodels. The "RSIR" procedure uses an asymptotic test on each element of the estimated EDR directions. It was translated from a Matlab code made by Peng Zeng. The "SR-SIR" procedure relies on a lasso penalty. The underlying parameter is chosen using the residual information criterion (RIC). It was written using a R code made by Lexin Li.

desc

edrSelc returns an object of class edrSelc, with some of the following attributes, depending on the value of method:

scoreVar A numeric vector filled with a score for each explanatory variable. Variables that have a high score should be kept. For the "CSS" method, the score is the presence of the variable in the 'best' submodels. For "RSIR", it is one minus the p-value of the test. For the "SR-SIR" procedure, it is a boolean that indicates if the variable should be kept when using the optimal lasso parameter.
The chosen dimension.
The chosen number(s) of slices.
The sample size.
The variable selection method used.
The matrix of the quantitative explanatory variables (bind by column).
The numeric vector of the dependent variable (a response vector).
A $N_\text{Zero} \times p_\text{Zero}$ matrix that contains the variables of each created submodel, for the "CSS" method.
A matrix with $p_\text{Zero}$ columns made of the variables of each 'best' submodel, for the "CSS" method.
A vector containing the squared correlation between indices for each submodel, for the "CSS" method.
A vector made of values of the Akaïke information criterion for every lasso parameter considered by the "SR-SIR" procedure.
A vector made of values of the Bayesian information criterion for every lasso parameter considered by the "SR-SIR" procedure.
A vector made of values of the residual information criterion for every lasso parameter considered by the "SR-SIR" procedure.
A list which gives, for each lasso parameter studied with the "SR-SIR" procedure, a matrix spanning the estimated EDR space.

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References


See Also

`edr`, `edrUnderdet`

Examples

```r
## Not run:
n <- 100
p <- 110
K <- 1
```
edrUnderdet

EDR space estimation for underdetermined cases.

Description
Gathers several procedures to estimate the effective dimension regression (EDR) space when the number of explanatory variables is greater than the sample size. Creates an object of class edr.

Usage
edrUnderdet(Y, X, H, K, method, initEDR=NULL, maxIter=NULL, regulParam=NULL, sMin=1e-16, sChg=10, btspsamp=NULL)

Arguments
Y A numeric vector representing the dependent variable (a response vector).
X A matrix representing the quantitative explanatory variables (bind by column).
H When method="SR-SIR" or method="RSIR", the chosen number of slices. When method="SIR-QZ", a vector with various numbers of slices.
K The chosen dimension K.
method This character string specifies the method of fitting. It should be either "SIR-QZ", "RSIR" or "SR-SIR".
initEDR When method="SR-SIR", a p x K matrix which contains initial values for the iterative algorithm that estimates EDR directions.
maxIter When method="SR-SIR", a maximum number of iterations after which the algorithm stops.
regulParam When method="SR-SIR" or method="RSIR", a vector containing possible values of the regularization parameter, from which the optimal one will be chosen.
sMin When method="SIR-QZ", the smallest regularization parameter to test.
sChg When method="SIR-QZ", a positive real by which a regularization parameter is multiplied to produce the next one to consider.
btspsamp When method="RSIR", the bootstrap sample size for estimating the mean squared error.
Details

The "SIR-QZ" method estimates the indices rather than the EDR directions. It makes use of several estimations from several numbers of slices. It tries to find a minimal regularization of the covariance matrix of $X$. The "RSIR" procedure uses a bootstrap estimator of the mean squared error of regularized estimates of the EDR directions. It was translated from a Matlab code made by Peng Zeng. The "SR-SIR" procedure relies on a generalized cross-validation criterion and on an alternating least squares algorithm to find an optimal regularization parameter. It was written using a R code made by Lexin Li.

Value

edrUnderdet returns an object of class edr, with some of the following attributes, depending on the value of method:

- matEDR: A matrix spanning the estimated EDR space.
- indices: The estimated indices from the "SIR-QZ" method.
- eigvalEDR: The eigenvalues of a matrix of interest.
- k: The chosen dimension.
- H: The chosen number(s) of slices.
- n: The sample size.
- method: The dimension reduction method used.
- X: The matrix of the quantitative explanatory variables (bind by column).
- Y: The numeric vector of the dependent variable (a response vector).
- s: The optimal regularization parameter(s) found by the chosen method.
- estmse: For each tested regularization parameter, the estimated mean squared error from the "RSIR" method.
- testedEDR: For each tested regularization parameter, a matrix spanning the estimated EDR space from the "SR-SIR" method.
- iter: For each tested regularization parameter, the number of iterations needed for the alternating least squares algorithm from the "SR-SIR" method to converge.
- gcv: For each tested regularization parameter, the corresponding generalized cross-validation criterion from the "SR-SIR" method.

Author(s)

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References


See Also

edr, sliceMat

Examples

```r
## Not run:
n <- 100
p <- 200
K <- 2
H <- 3:8
beta1 <- c(1,1,1,1,rep(0,p-4))
beta2 <- c(rep(0,p-4), 1,1,1,1)
X <- rmvnorm(n,sigma=diag(p))
eps <- rnorm(n,sd=10)
Y <- (X*X%*%beta1)^3 + (X*X%*%beta2)^3+eps
result <- edrUnderdet(Y,X,H,K,"SiR-QZ")
summary(result)
plot(result)
```

```
## End(Not run)
```
Value

Returns graphs.

Author(s)

Benoît Liquet, <benoit.liquet@isped.u-bordeaux2.fr> and Jérôme Saracco <jerome.saracco@math.u-bordeaux1.fr>

References


See Also

`criterionRkh`

Examples

```r
## see example in function criterionRkh
```

---

**plot.edr**

*Basic plot of an edr object*

Description

For an edr object with attributes $K \leq 2$, this function plots the response $y$ versus each new estimate indice with an estimation of the link function. For $K = 2$, a 3D plot of $y$ versus the two estimate indices is represented. A smooth estimate of the link function is also represented. For $K > 2$, the pairs function is used.

Usage

```r
## S3 method for class 'edr'
plot(x, ...)
```

Arguments

- `x` The name of an object of class `edr`.
- `...` Some methods for this generic require additional arguments. None are used in this method.

Value

Returns graphs.
Author(s)

Benoît Liquet, <benoit.liquet@isped.u-bordeaux2.fr> and Jérôme Saracco <jerome.saracco@math.u-bordeaux1.fr>

See Also

summary.edr

Examples

```
## simulated example
set.seed(10)
n <- 500
beta1 <- c(1,1,rep(0,8))
beta2 <- c(0,0,1,1,rep(0,6))
X <- rmvnorm(n,sigma=diag(1,10))
eps <- rnorm(n)
Y <- (X%*%beta1)**2+(X%*%beta2)**2+eps
edr2 <- edr(Y,X,H=2,K=2,method="SIR-II")
#plot(edr2)
## edr4 <- edr(Y,X,H=2,K=4,method="SIR-II")
## plot(edr4)
```

plot.edrSelec

Displaying methods for the class 'edrSelec'

Description

Methods to present the results of a variable selection procedure based on slice inverse regression.

Usage

```
## S3 method for class 'edrSelec'
print(x, ...)
## S3 method for class 'edrSelec'
summary(object, nVar=5, ...)
## S3 method for class 'edrSelec'
plot(x, nVar=25, ...)
```

Arguments

- `x` An object of class edrSelec generated by the function `edrSelec`.
- `object` An object of class edrSelec generated by the function `edrSelec`.
- `nVar` If `nVar=NULL`, the method will only show the `nVar` most important variables with respect to the criterion computed by the function `edrSelec`. Not implemented for the summary method when executed with a "SR-SIR" procedure.
- `...` Other unused parameters.
Value
These methods display (with a text or a graphic) the score of each considered variable. The user should keep the variables with a high score.

Author(s)
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See Also
edrSelec, edrUnderdet, edr

Examples
## see the example of the function edrSelec.
print.edr  
*Print a Summary of an edr Object*

**Description**

This is a method for the function print for objects of the class edr.

**Usage**

```r
## S3 method for class 'edr'
print(x, ...)
```

**Arguments**

- `x`: An object of class edr generated by the function edr.
- `...`: Further arguments to be passed to or from other methods. They are ignored in this function.

**Value**

A summary of the edr Object is returned.

**Author(s)**

Benoît Liquet, <benoit.liquet@isped.u-bordeaux2.fr> and Jérôme Saracco <jerome.saracco@math.u-bordeaux1.fr>

**See Also**

edr

---

sliceMat  
*Slicing matrix computation*

**Description**

Returns the slicing matrix required for the "SIR-I" method.

**Usage**

```r
sliceMat(Y, X, H, details=FALSE, rdSup=FALSE)
```
sliceMat

Arguments

Y
A numeric vector representing the dependent variable (a response vector).

X
A matrix representing the quantitative explanatory variables (bind by column).

H
The chosen number of slices.

details
A boolean that determines whether or not some matrices used to construct the slicing matrix should be sent back. See also 'Value'.

rdSup
When the number of slices is not a divisor of the sample size, this boolean determines whether or not the slices which contain an extra point are randomly chosen.

Details

This function divides the range of Y in H distinct intervals, or slices. It then puts every row of X into a slice with respect to the corresponding element of Y. It finally computes a matrix $M = X_h^t P_h X_h$ where each row of $X_h$ is the mean vector over the vectors of X that belong to a given slice. The matrix $P_h$ is diagonal and contains the number of rows of X placed in each sliced. The matrix $M$ is required when trying to perform a sliced inverse regression.

Value

If details=FALSE, the $p \times p$ slicing matrix $M$, where $p$ is the number of columns of $X$.

If details=TRUE, a list made of $M$, $X_h$ and $P_h$.

Author(s)

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See Also

edr, edrUnderdet

Examples

#The "SIR-I" method whithout using 'edr'
n <- 500
p <- 5
H <- 10
beta <- c(1, 1, 1, 0, 0)
X <- rmvnorm(n,rep(0,p),diag(p))
eps <- rnorm(n, 0, 10)
Y <- (X %*% beta)^3 + eps
M <- sliceMat(Y,X,H)
hatBeta <- eigen(solve(var(X)) %*% M)$vectors[,1]
cor(hatBeta,beta)^2
### summary.criterionRkh

**Print a Summary of a criterionRkh Object**

#### Description

This is a method for the function `summary` for objects of the class `criterionRkh`.

#### Usage

```r
## S3 method for class 'criterionRkh'
summary(object, ...)
```

#### Arguments

- `object` An object of class `criterionRkh` generated by the function `criterionRkh`.
- `...` Further arguments passed to or from other methods.

#### Value

A summary of the `criterionRkh` Object is returned.

#### Author(s)

Benoit Liquet, <benoit.liquet@isped.u-bordeaux2.fr> and Jérôme Saracco <jerome.saracco@math.u-bordeaux1.fr>

#### See Also

- `criterionRkh`

### summary.edr

**Print a Summary of an edr Object**

#### Description

This is a method for the function `summary` for objects of the class `edr`.

#### Usage

```r
## S3 method for class 'edr'
summary(object, ...)
```

#### Arguments

- `object` An object of class `edr` generated by the function `edr`.
- `...` Further arguments passed to or from other methods.
Value

A summary of the edr Object is returned.

Author(s)

Benoît Liquet, <benoit.liquet@isped.u-bordeaux2.fr> and Jérôme Saracco <jerome.saracco@math.u-bordeaux1.fr>

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